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PROPOSAL

for

SUBMINIATURE RECORDER

to

[redacted]

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7 January 1954

Proposal Number

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PROPOSAL FOR SUBMINIATURE RECORDER

I. The Problem: One of the long range, basic problems of operations is the provision of a subminiature, rugged, recording device which can be used with a variety of input units in a simple manner. Although the recorder should be extremely straightforward in design, with a minimum of adjustments, a redeeming factor is that information need not be instantly readable from the record by eye. In other words, the "gadgetry" required for extremely high resolution recording can be concentrated in a reading device rather than thr recorder.

From the standpoints of equipment maintenance and cost it appears advantageous to use this pattern, since one "reader" can be used to service a good many recorders. The recorded signal would be meaningless without a reader, but this provides a sort of natural coding which will be of a very unique nature.

Some tentative specifications may be set up for the proposed project, although it is hoped that some of these may be bettered as a result of the work:

1. Duration of Recording: At least 30 minutes.
2. Frequency Response: 0-2500 cycles/second

Note: A single cycle of a sine wave may be considered to carry two "bits" of information, since it crosses the reference axis twice, once with positive slope and once with negative slope. Thus the total storage capacity C of the device described would be:

$$C = 2 \times 2500 \times 60 \times 30 = 9 \times 10^6 \text{ bits}$$

3. Total Storage Capacity: 9×10^6 bits

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4. Power Supply: Self-contained

Note: It is visualized that a spring-driven motor might drive the "chart", and that the power required to actually make the record will be derived either from a source of electrical or chemical energy. However this constitutes one of the major design problems, and means for supplying power should not be finalized now!

5. Weight: Not more than 1 pound.

6. Dimensions: Not greater than 3/4" x 4" x 5"

7. Input: 1 volt across 600 ohms (R.M.S.)

II. Problem Discussion: Ordinary microfile film has a resolving power of 135 lines/mm., and spectrographic film exeeds this, perhaps by an order of magnitude. There is vague data available from a British inventor to indicate much higher storage capacity for film. The exposure time increases for higher resolution film, so that one best compromise exists between the maximum number of bits per square inch which can be stored, and the energy required per bit of information stored.

Since any sort of photographic film requires some processing use of film is not obligatory. However it may be calculated that the number of bits which can be stored on microfile is $(135)^2$ per $mm.^2$ or $(135 \times 25.4)^2$ per $in.^2$. The latter figure is about 11.7×10^6 bits/in^2, so that the required 30 minutes of speech theoretically can be stored in one square inch of microfile.

The theoretical density of storage could be obtained very nearly by moving the film in a straight line along one edge (of a square), and moving one space along one edge (of a square), and moving one space in a perpendicular direction at the end of each line. This means of programming is difficult to achieve mechanically, and a compromise plan will sacrifice bit density. Other sacrifices must be made to permit reasonable mechanical tolerances in the mechanism, since to position the film accurately to within one track width would require tolerances of about $(0.1)(1/25.4 \times 135)$ or .00003 in.

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The most practical commercial recording form seems to be the belt developed by Dictaphone. For example, a belt has a surface area π DW sq.in., where D is the belt diameter and W is the belt width. If we choose W-D, then the area, A = πD^2. For a disc having the same diameter, the area, A = $\pi D^2/4$, so the belt has four times the area for the same physical size. If we need 10 sq. in. of belt surface, the length and width of a "square" belt would be only 1.75 in. Present Dictaphone belts have a width of 3.5 in. and a total area of about 42 sq. in.

The chart record might first be visualized as a belt having a diameter of 3" and an equal width -- perhaps with sprocket holes for indexing purposes. The belt geometry allows good tracking with linear motion of the recording head, and a helical track, using the area rather effectively. On this basis it will be necessary to store 9×10^6 bits in an area of 27 sq. in, or 3.3×10^5 bits/sq. in. The linear dimension of a bit is .00175 in., so that the speed of the belt will need to be about 8.8 in/sec. For a 1" circumference driving drum, this would correspond to about 510 rpm. Evidently, the power requirement for 1/2 hour at this rate would be excessive. A clock-work motor would be hard-ressed to supply this much energy.

Drive: The Esterline-Angus chart recorder uses a spring clock in some models, and will drive a rather large charge and takeup mechanism at speeds up to 6 inches per minute for as long as 4 hours, almost the equivalent of 48 inches per minute for 30 minutes. The Esterline-Angus escapement design is not new, and modern techniques might bring the drive speed of a much smaller chart (less takeup mechanism) up to perhaps 100 inches per minute for 30 minutes, while reducing size and weight.

Thus, 1.67 in/sec. seems reasonable, and this is within a reasonable range of a belt diameter which does not place too severe tolerance requirements on the mechanical system.

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Means of Recording: The load of the pen on the Esterline-Angus chart does not particularly increase power requirements; however, the means of marking a chart should probably not involve a pen which contacts the chart. To record a bit, only choice of a light or dark area (or some other "on" or "off" area) is necessary.

Exploration of this field will be an important part of the research program, since extremely high resolution is required. With an area per bit of less than 0.001 in. in length, as may be necessary, we are working at the small end of the useful range of mechanical devices (such as a microgroove phonograph stylus tip).

New methods which will be reviewed may include use of a very tiny flame to mark ordinary paper. If a properly-designed burner can be fabirciated, a fuel such as propane or methane-carried in a tiny pressurized container- could be ignited for a short pulse of heat. Spark ignition is possible, as is combustion by injection of another gas in a short burst.

If the proper medium is found, marking might even be accomplished by a burst of gas such as bromine (or a less violent chemical) directed against the chart. Gas is greatly preferable to a liquid to avoid pen clogging, and a pressurized container containing the gaseous material, but in a liquid phase, furnishes a continuous feed mechanism.

It is even possible to consider an escapement type of mechanism driven by heat obtained from such a fuel source, for use as a drive mechanism.

III. Proposed Program: Since the best fundamental system to be used is not now obvious, it is proposed that a preliminary basic study, directly useful in itself, be undertaken how. This study would undeetake to conduct experimental investigations of basic recorder principles, and to determine optimum design specifications for a realistic model.

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By analysis of the type briefly used in earlier paragraphs of this proposal it is believed possible to make a systematic search of all possible methods and systems, and to accept or reject basic ideas. This sort of screening is of advantage in any development project, and has a lasting value if comparable system elements are reduced to fundamental characteristics.

Clearance will be requrested to visit Defense Department laboratories or commercial firms working on recording systems, to discuss basic limitations of various recording processes. A critical survey of this work, as well as all pertinent recent literature, will be included.

IV.. Estimated Cost and Duration of Project: It is believed that a period of nine months will allow sufficient time for a thorough study. The following costs are anticipated. Figures in parenthese represent per cent of full time of the staff member concerned:

A. Direct Salaries

Senior Research Physicist (30%).....

Research Engineer (75%) .....

Technician (60%) .....

Total Salaries.....

B. Direct Materials

Electrical & Electronic Parts .....

Mechanical & Materials .....

Total Materials.....

C. Direct Expenses

Travel .....

Telephone, etc.....

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D. General and Administrative Expense [redacted] ..... [redacted] 25X1

E. Total Estimated Cost ..... [redacted]

F. Fixed Fee: [redacted] ..... [redacted] 25X1

G. TOTAL ESTIMATED [redacted]

V. Facilities and Personnel: Data on facilities and personnel is already on file. It is anticipated that the writer of this proposal will serve as principal investigator, assisted by an engineer with 5-10 years' experience and a competent research technician.

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By:

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Physics Department

PME/w

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